In the case of L≧3, the intermediate recording pulse group was set to constant values: $\alpha_i'=\alpha_i=1$ and $\beta_i'=\beta_i=1$ (2≦i≦m−1), and $\alpha_m=\alpha_m'=1$. For L≧2, they were set to constant values, not dependent on the n value: $\alpha_1=\alpha_1'=1.05$ and $\beta_m=\beta_m'=0.4$.

Further, in the case of 3T, a 3T mark length was obtained with $T_{d1}=1.15$, $\alpha_1=1.2$ and $\beta_1=0.8$. In FIG. 26, the recording pulse section and the off pulse section are represented by the top and bottom portions of the rectangular wave. Specific lengths of sections are indicated by numbers, and the depicted lengths of the top and bottom portions in the figure do not correspond to the lengths of the sections.

The bias power Pb_i was set to a fixed value Pb=0.5 mW, not dependent on the i value, and the erase power Pe was set to 4.5 mW. The recording power Pw_i was also set to a fixed value irrespective of the i value. After overwriting 9 times, the edge-to-clock jitter and the dependency of the modulation on the recording power were measured. Retrieving was performed using the reproducing light power of Pr=0.8 mW and the linear velocity of 3.5 m/s. At either recording linear velocity and with the recording power of 15.0 mW, the edge-to-clock jitter was less than 10% and the modulation achieved 60% or higher, as shown in FIGS. **27**(*a*) and **27**(*b*). R_{top} was about 18%. Measurement of the overwrite dependency at the recording power of 15.0 mW found that, as shown in FIG. **27**(*c*), the edge-to-clock jitter was 11% or less even after 10,000 overwrite operations. At this time R_{top} and the modulation exhibited almost no change with the overwrite.

Further, a pulse dividing method of FIG. 28 based on the divided recording pulse generating method 3 described above was performed on the similar disk by recording an EFM+ modulation signal at a linear velocity of 7 m/s, equivalent to two times the DVD linear velocity, and a clock frequency of 52.5 MHz (clock period of 19.1 nsec).

As in the case with 4 and 4.8 times the DVD speed, the bias power was set constant at Pb=0.5 mW and the erase power Pe at 4.5 mW. The recording power Pw_i was also set constant, not dependent on the i value. After nine overwrite operations, the edge-to-clock jitter and the recording power dependency of the modulation were measured. As shown in FIGS. **27**(*a*) and **27**(*b*), at the recording power of 13.0 mW, the edge-to-clock jitter was less than 8% and the modulation achieved 57% or higher. R_{top} was about 18%. At the recording power of 13.0 mW, the overwrite dependency was measured and it was found that, as shown in FIG. **27**(*c*), the edge-to-clock jitter was below 11% even after 10,000 overwrite operations. At this time R_{top} and the modulation exhibited almost no change with the overwrite.

From the above discussion, it is understood that the use of the pulse dividing method based on the divided recording pulse generation method 3 enables recording in a linear velocity range of 2 to 4.8 times the DVD linear velocity. Hence, with this method the recording with a constant angular velocity can be performed in a radial range, for example, from about 24 mm to about 58 mm, which constitutes a data area of DVD.

INDUSTRIAL APPLICABILITY

According to this invention, even when the reference clock period is short, a satisfactory mark length modulation recording can be performed, allowing a higher density and a faster recording of the optical recording media. This in turn leads to an increase in the recordable capacity of the optical disk and enables the recording speed and transfer rate of the optical disk to be enhanced, greatly expanding the range of its applications for recording large amounts of data such as music and video and for external storage devices of computers. For instance, it is possible to realize a rewritable CD that overwrites EFM modulation marks at speeds more than 12 times the CD linear velocity and a rewritable DVD that overwrites EFM+ modulation marks at speeds more than 4 times the DVD linear velocity.

What is claimed is:

1. An optical recording method for recording mark length-modulated information with a plurality of recording mark lengths by irradiating a recording medium with a light, the optical recording method comprising the steps of:

when a time length of one recording mark is denoted nT (T is a reference clock period equal to or less than 25 ns, and n is a natural number equal to or more than 2), dividing the time length of the recording mark nT into

$$\eta_1 T, \alpha_1 T, \beta_1 T, \alpha_2 T, \beta_2 T, \ldots, \alpha_i T, \beta_i T, \ldots, \alpha_m T, \beta_m T, \eta_2 T$$

in that order (m is a pulse division number; [Σhdi] $\underline{\Sigma_i}(\alpha_i+\beta_i)+\eta_1+\eta_2=n$; α_i [(1≦i≦m-1)] $\underline{(1 \leq i \leq m)}$ is a real number larger than 0; βi (1≦i≦m-1) is a real number larger than 0; β_m is a real number larger than or equal to 0; $\alpha i+\beta i$ (2≦i≦m-1) or [β_i−1] $\underline{\beta_{i-1}}+\alpha_i$ (2≦i≦m-1) is kept constant independently of said real number I; and η_1 and η_2 are real numbers between -2 and 2);

radiating recording light with a recording power Pw_i in a time duration of $\alpha_i T$ (1≦i≦m); and

radiating recording light with a bias power Pb_i in a time duration of $\beta_i T$(1≦i≦m−1), the bias power being $Pb_i<Pw_i$ and $Pb_i<Pw_{i+1}$;

wherein the pulse division number m is 2 or more for the time duration of at least one recording mark and meets n/m≧1.25 for the time length of all the recording marks,

further wherein when the same pulse division number m is used on at least two recording marks with different n values, a difference mark length is formed by changing at least one of β_1, β_{m-1}, and βm.

2. An optical recording method according to claim 1, wherein $\alpha_i+\beta_i$ (2≦i≦m-1) or [β_i−1] $\underline{\beta_{i-1}}+\alpha_i$ (2≦i≦m-1) is 2 independently of said real number i.

3. An optical recording method according to claim 1, wherein α_i is kept constant as a constant value αc where said is (2≦i≦m−1).

4. An optical recording method according to claim 1, wherein α_i (2≦i≦m−1) is kept constant in the time length of the recording mark with having a pulse division number m being at least 3.

5. An optical recording method according to claim 1, wherein when performing a mark length modulation scheme recording on the same recording medium by using a plurality of linear velocities v while keeping v×T constant,

for m equal to or greater than 2, $(\alpha_i+\beta_i)$ in 2≦i≦m−1 is kept constant independently of the linear velocity [Pw_1] $\underline{Pw_i}$, Pb_i and Pe in each i are kept almost constant independently of the linear velocity and αi (2≦i≦m) is decreased as the linear velocity lowers.

6. An optical recording method according to claim 1, wherein when performing a mark length modulation scheme recording on the same recording medium by using a plurality of linear velocities v while keeping v×T constant,

for m equal to or greater than 2, ([β_i-1] $\underline{\beta_{i-1}}+\alpha_i$) in 2≦i≦m are kept constant independently of the linear velocity, [Pw_1] $\underline{Pw_i}$,[Pb_1] $\underline{Pb_i}$ and Pe in each I are kept almost constant independently of the linear velocity, and α_i (2≦i≦m) are decreased as the linear velocity lowers.

7. An optical recording according to claim 5 or 6, wherein $\alpha_i T$ ($2 \leqq i \leqq m-1$) is kept almost constant independently of the linear velocity.

8. An optical recording method according to claim 1, the phase change type optical recording medium having a recording layer made of $M_z Ge_y (Sb_x Te_{1-x})_{1-y-z}$ alloy (where [$0 \leqq z \leqq 0.1$] $\underline{0 \leq z \leq 0.1}$ [$0 < y \leqq 0.3$] $\underline{0 < y \leq 0.3}$, $0.8 \leq x$; and

M is at least one of In, Ga, Si, Sn, Pb Pd, Pt, Zn, Au, Ag, Zr, Hf, V, Nb, Ta, Cr, Co, Mo, Mn, Bi, O, N and S).

9. An optical information recording medium having a recording layer, containing excessive Sb in SbTe eutectic point, in which phase change is made reciprocally between a crystal state and amorphous state with optical characteristic being differed from each other by irradiation of an optical beam, wherein said crystal condition is defined as polycrystal made of a substantial single crystal phase of a hexagonal crystal.

10. An optical information recording medium according to claim 9, wherein said recording layer is made of $M_z Ge_y (Sb_x Te_{1-x})_{1-y-z}$ alloy (where $0 \leqq z \leqq 0.1$ $0 < y \leqq 0.3$, $0.8 \leqq x$; and

M is at least any one of In, Ga, Si, Sn, Pb, Pd, Pt, Zn, Au, Ag, Zr, Hf, V, Nb, Ta, Cr, Co, Mo, Mn, Bi, O, N and S).

11. An optical information recording medium according to claim 9 or 10, wherein said crystal state of said recording layer is defined as an unrecorded state [and an erased state, while said amorphous state thereof is defined as a recorded state] and an erased state, while said amorphous state thereof is defined as a recorded state so as to [performed] <u>perform</u> recording or erasing of information.

12. A method of manufacturing an optical information recording medium having a recording layer, containing excessive Sb in SbTe eutectic point, in which phase change is made reciprocally between a crystal state and amorphous state with optical characteristic being differed from each other by irradiation of an optical beam, wherein

an initialization step is performed with another optical beam having an elliptical beam shape of which minor axis is 0.1–10 μm after forming at least said recording layer on a substrate, by scanning said another optical beam to the recording layer in a direction of said minor axis so as to make the recording layer in the crystal state, further wherein

said scanning of said optical beam is performed in a speed in a range of 50–80% of a maximum usable linear velocity for over-writing of the recording layer.

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